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(54) **SYSTEM FOR CONVEYING DRILL CUTTINGS**

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B65G 37/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B65G 67/606*** (2013.01); ***B63B 25/02*** (2013.01); ***B63B 25/04*** (2013.01); ***B63B 27/20*** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 141/104, 237, 242; 198/734; 222/199, 222/502, 503, 508, 556, 559, 565; 414/137.5, 137.8, 137.9, 138.2, 138.3, 414/138.5, 138.6, 138.7, 139.1, 139.3, 414/139.7, 140.2, 140.8, 140.9, 141.5, 414/142.1, 142.3, 142.4, 142.5, 142.9, 414/143.2, 803; 701/124; 73/65.04
See application file for complete search history.

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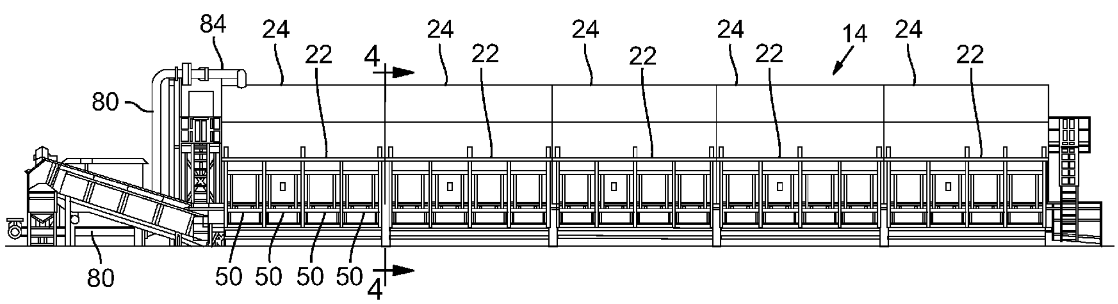
Primary Examiner — Gregory Adams
(74) *Attorney, Agent, or Firm* — Klarquist Sparkman, LLP

(57) **ABSTRACT**

The present disclosure concerns a system for transporting drill cuttings from an offshore drilling platform. In a representative embodiment, a bulk material storage and conveying system for a waterborne vessel comprises a first conveyor system including one or more upper conveyors extending lengthwise of the vessel. The system also comprises a plurality of containers located below the first conveyor system arranged in one or more rows, and a second conveyor system including one or more lower conveyors located below the one or more containers. The first conveyor system is configured to selectively dispense bulk material into the one or more containers, and the plurality of containers are configured to selectively dispense bulk material onto different locations along the length of the one or more lower conveyors. The system can further include an offloading conveyor assembly configured to convey drill cuttings from the lower conveyors to trucks on land.

10 Claims, 12 Drawing Sheets



(51) **Int. Cl.**

B63B 27/00	(2006.01)
B63B 25/02	(2006.01)
B63B 25/04	(2006.01)
B65G 63/00	(2006.01)
B65G 19/28	(2006.01)
B65G 47/51	(2006.01)

(52) **U.S. Cl.**

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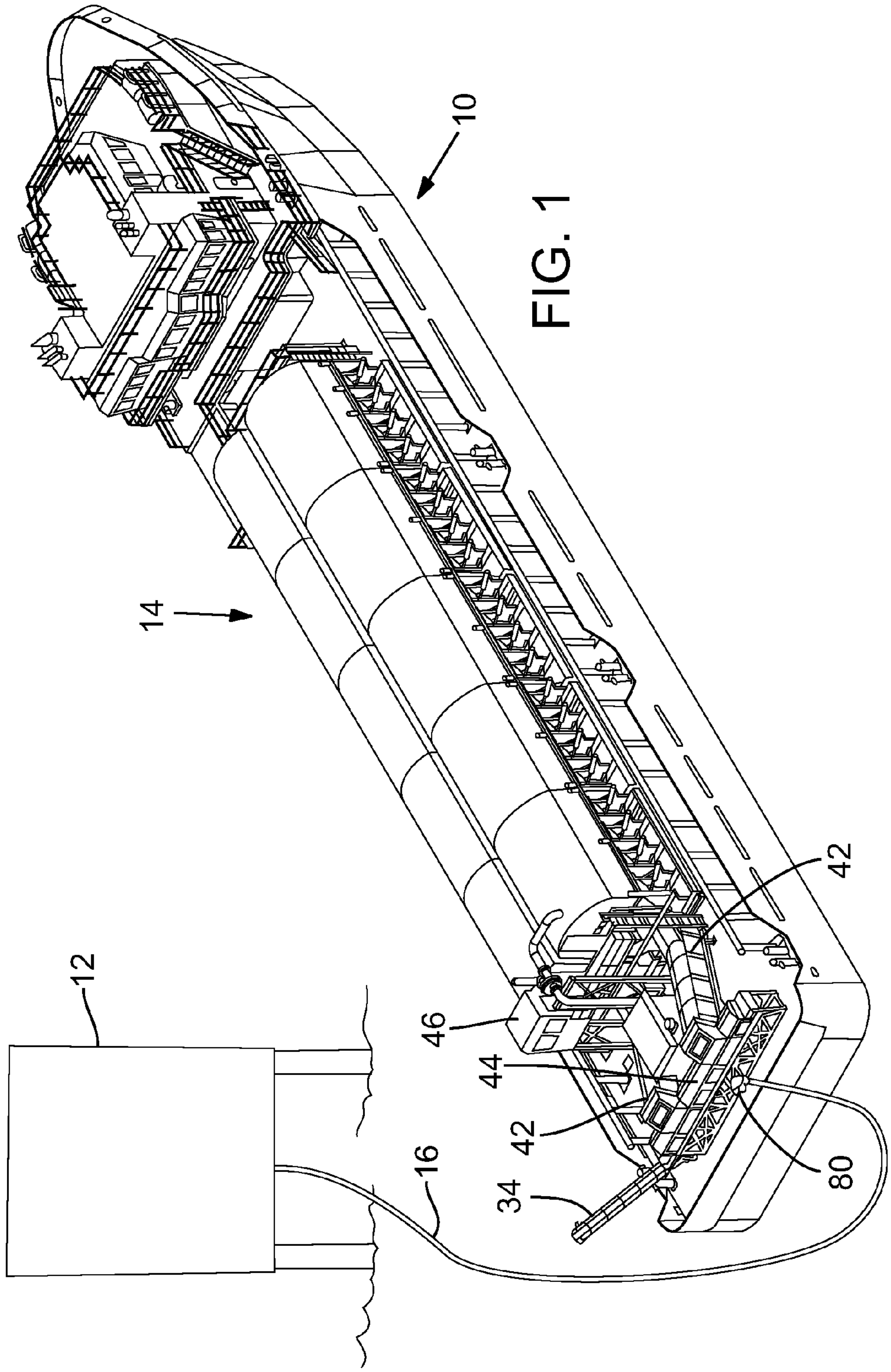


FIG. 1

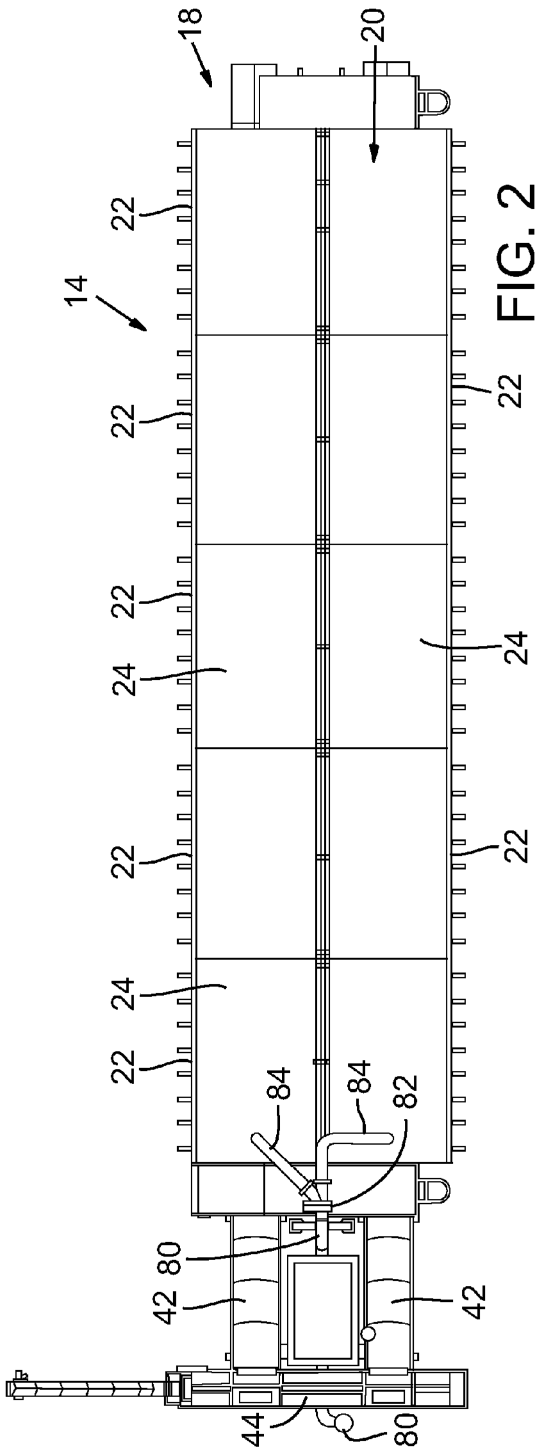


FIG. 2

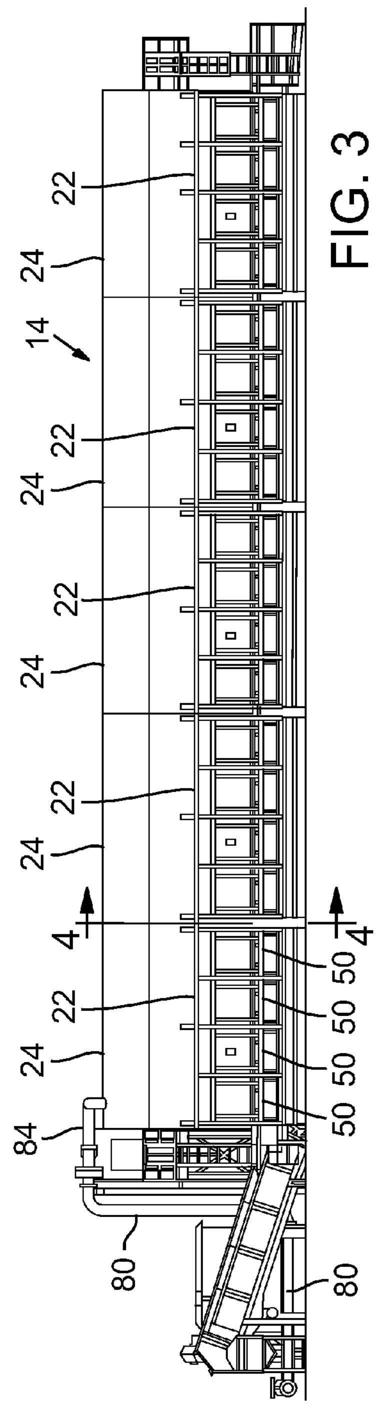
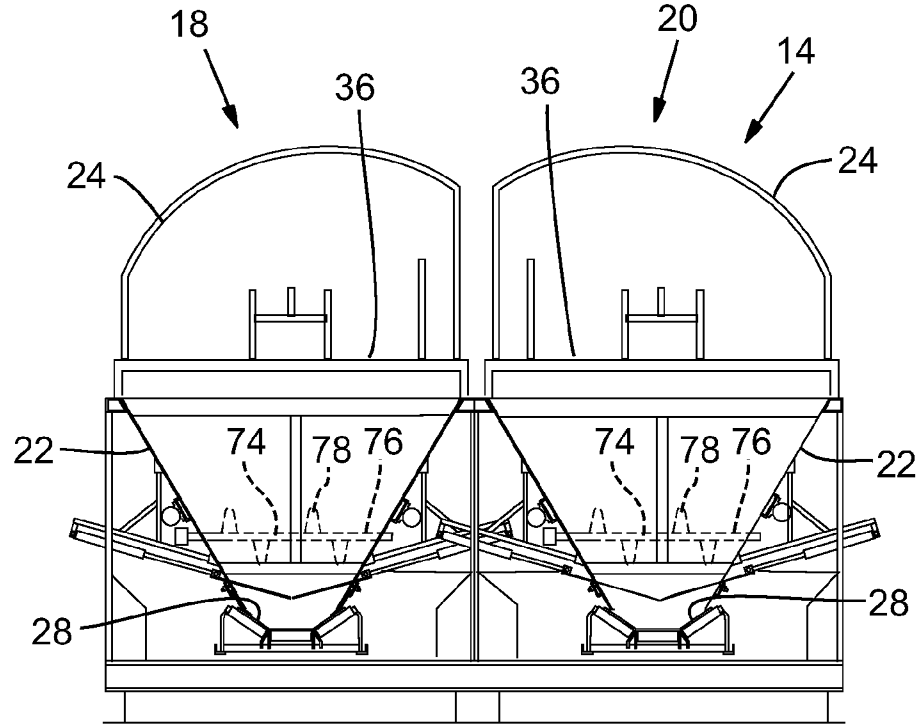


FIG. 3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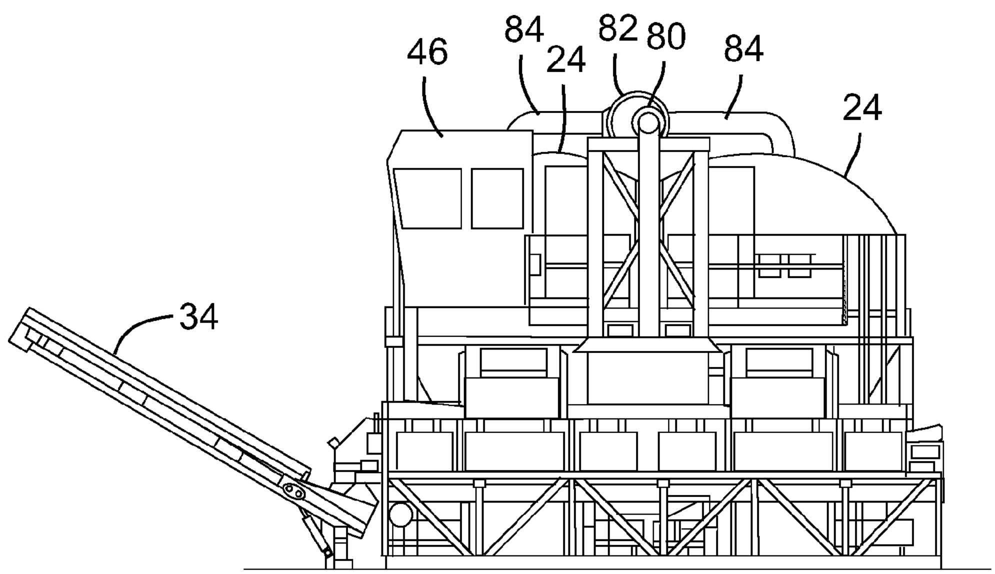
28

FIG. 4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84
24
82
80
84
24
34

FIG. 5

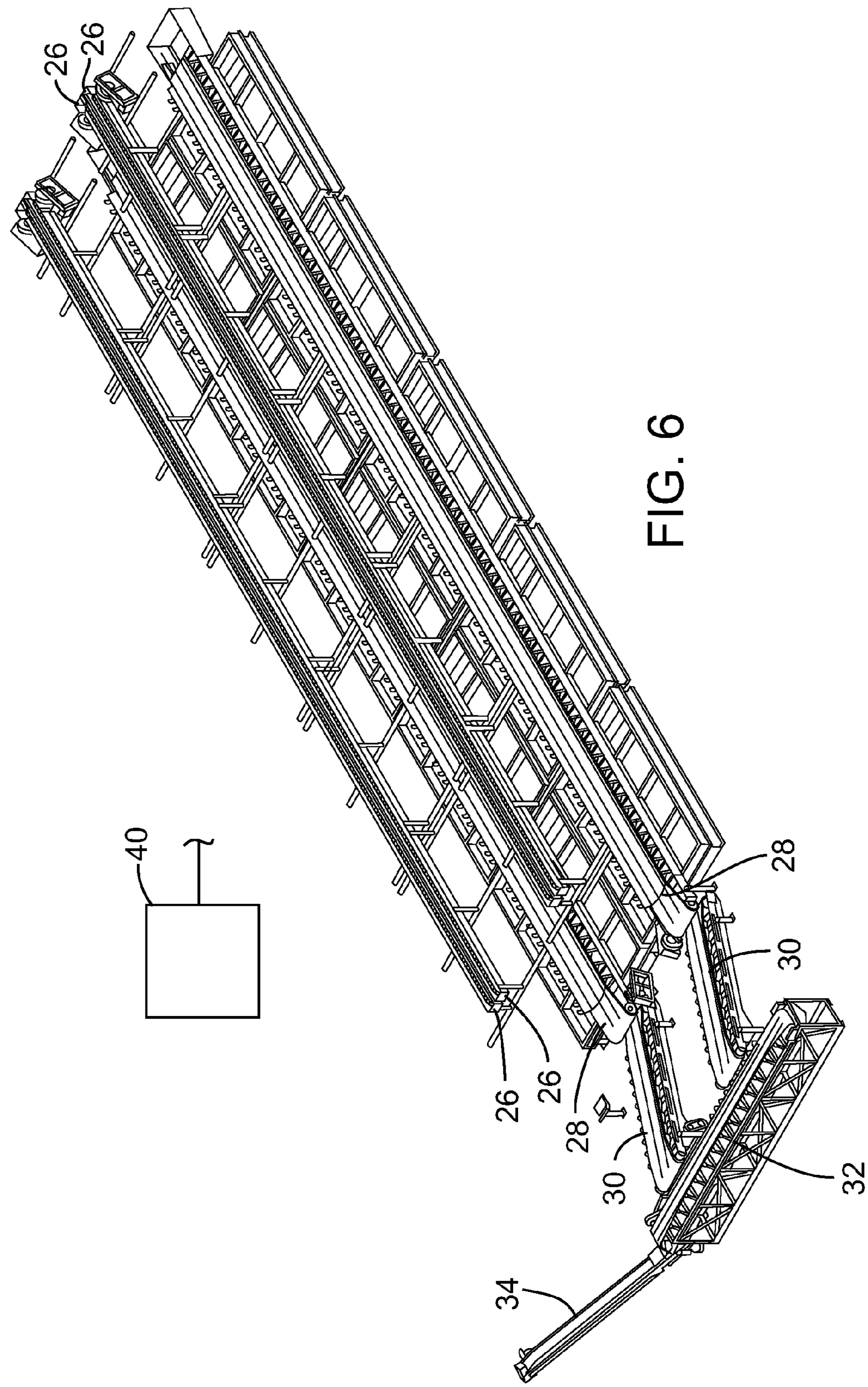


FIG. 6

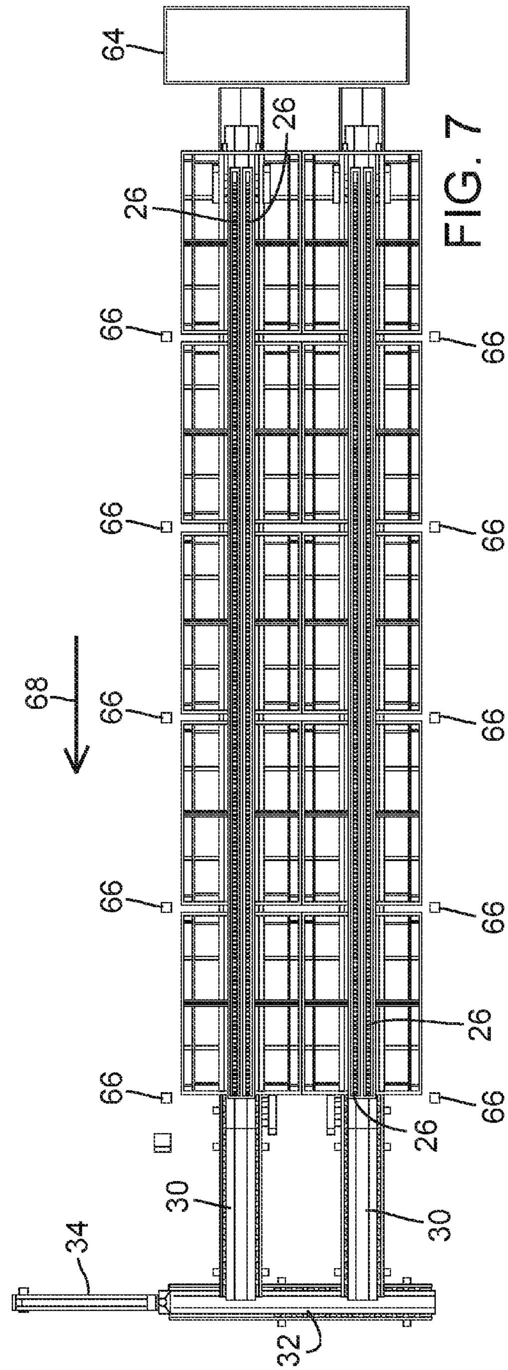


FIG. 7

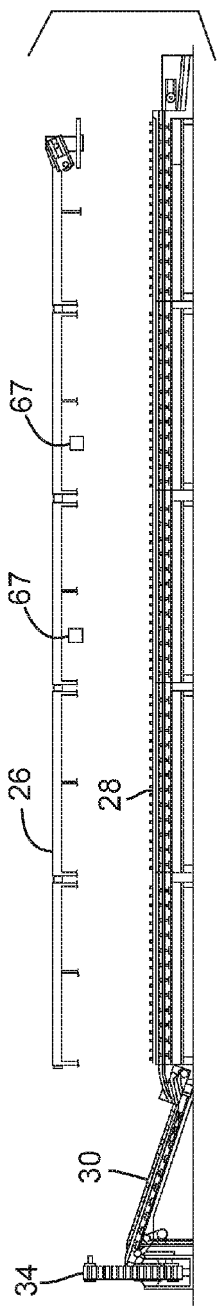


FIG. 8

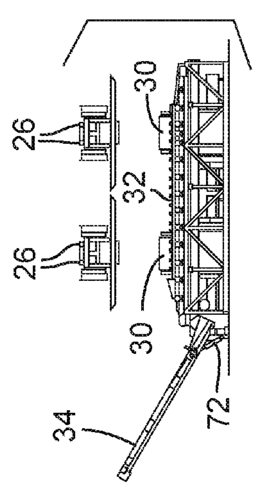
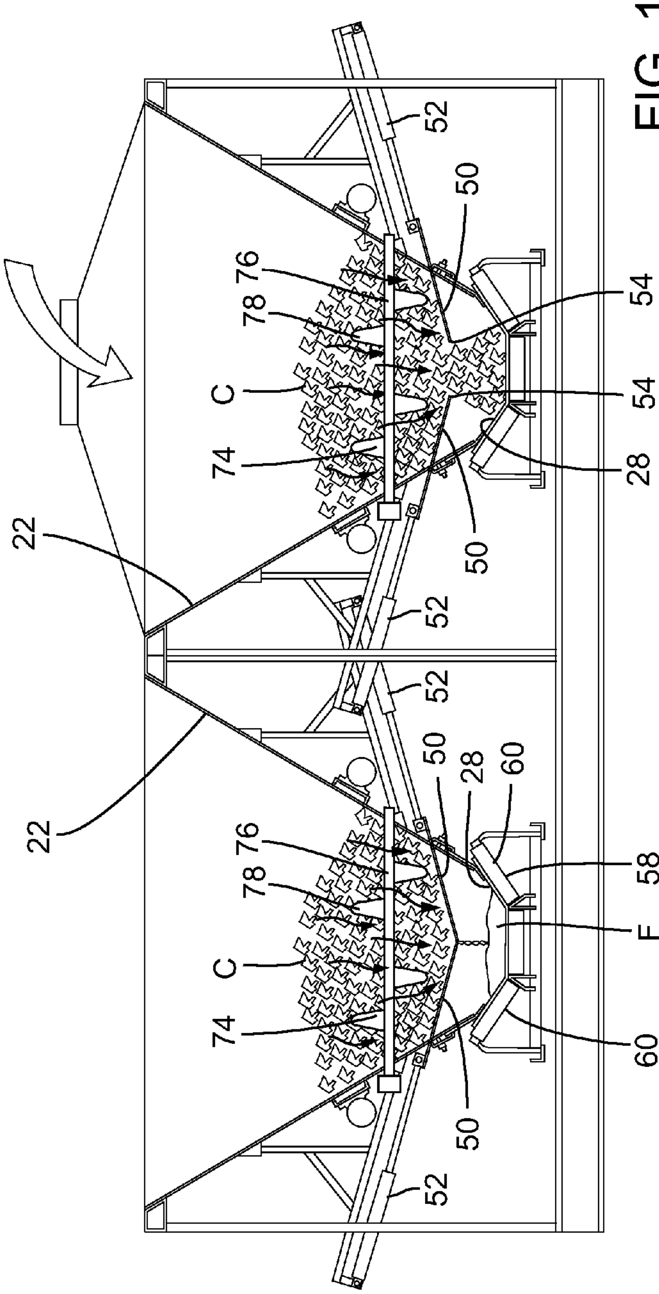


FIG. 9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22
C
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76
50
28
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F
60
52

FIG. 10

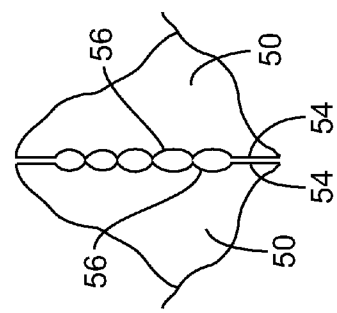
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FIG. 11

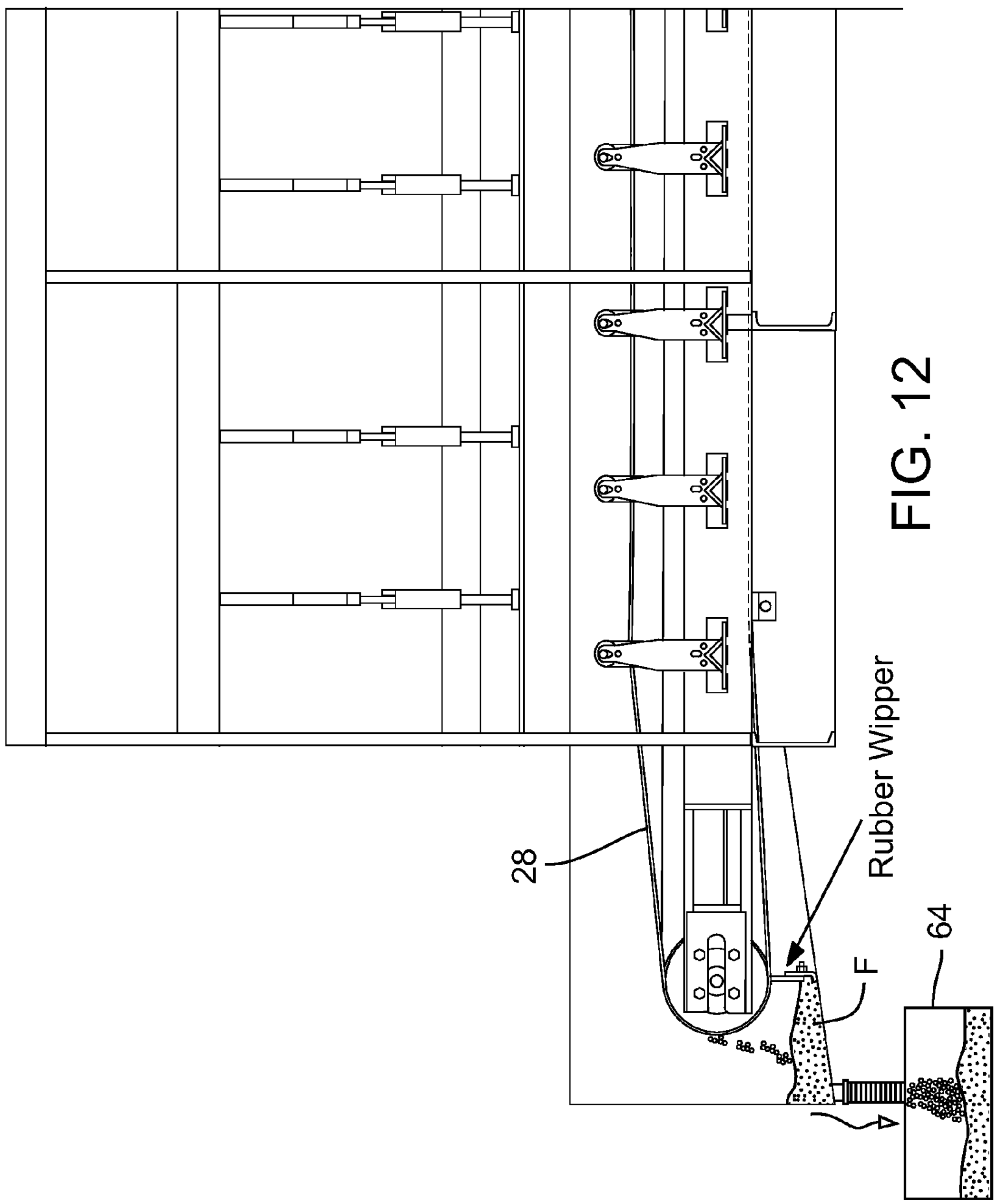


FIG. 12

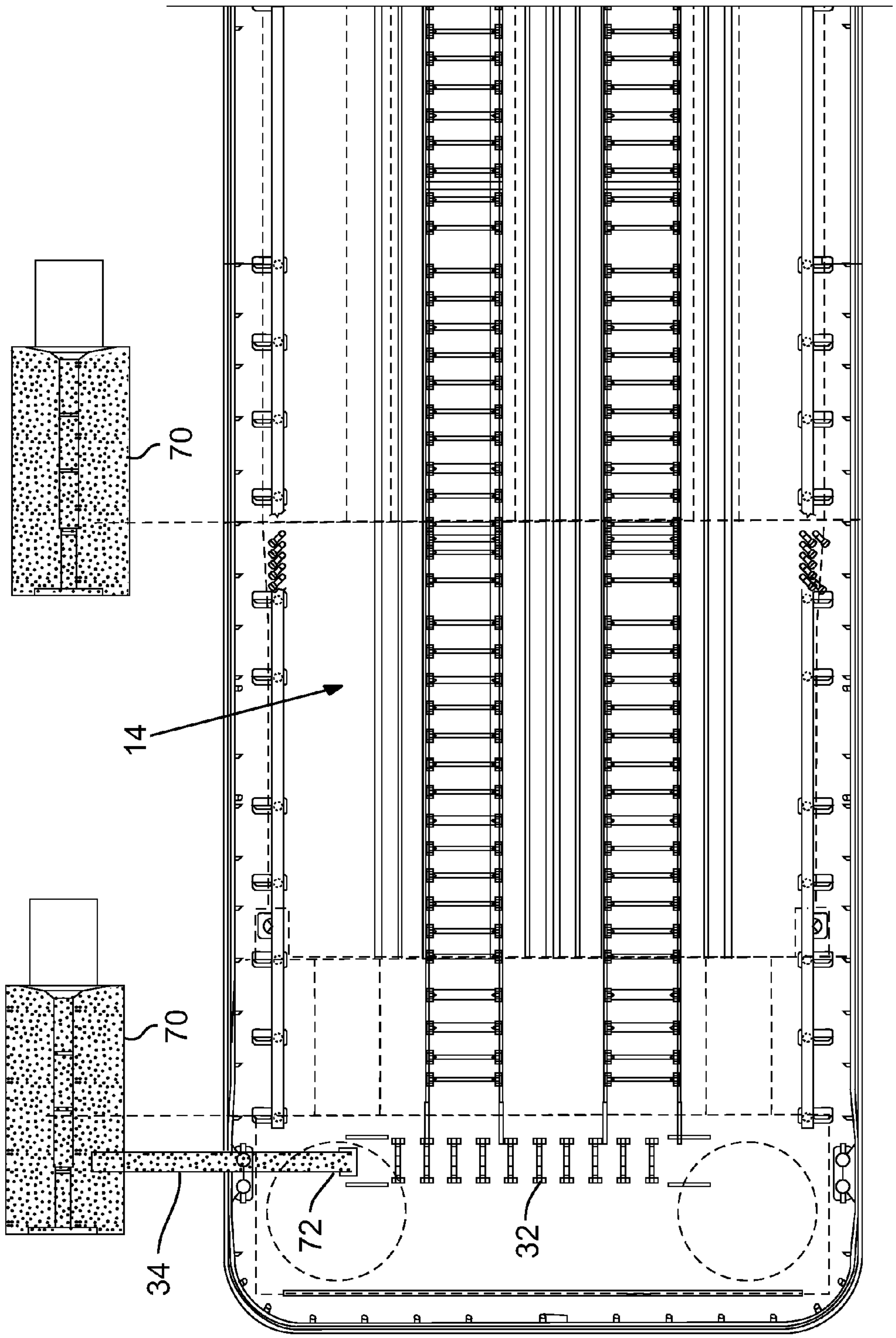


FIG. 13

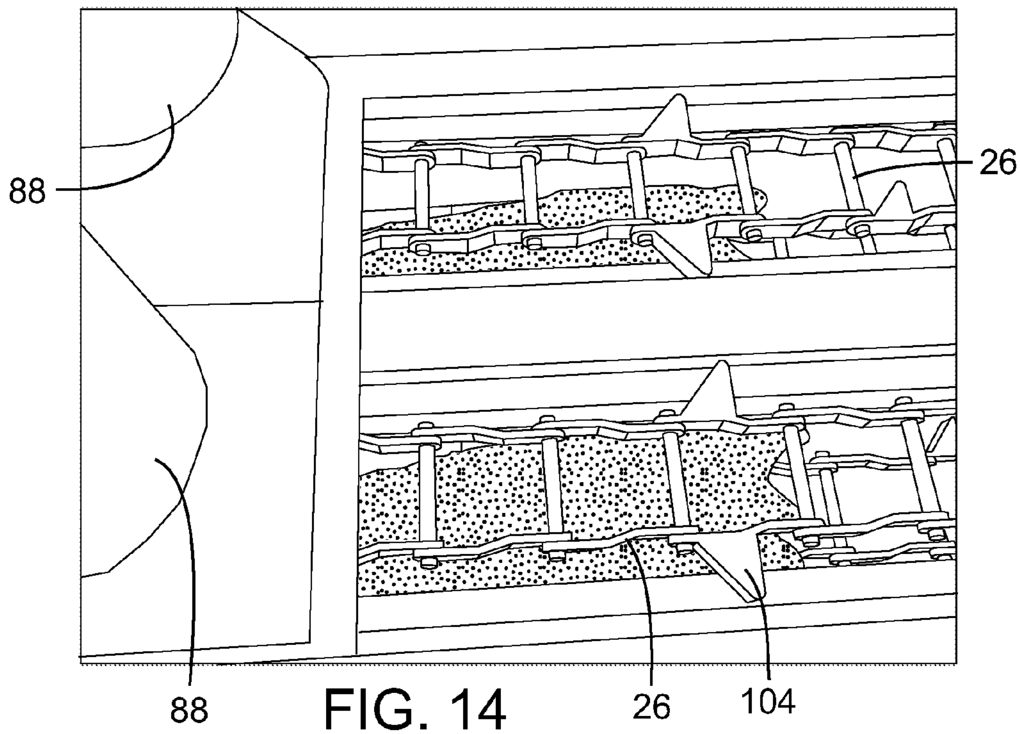


FIG. 14

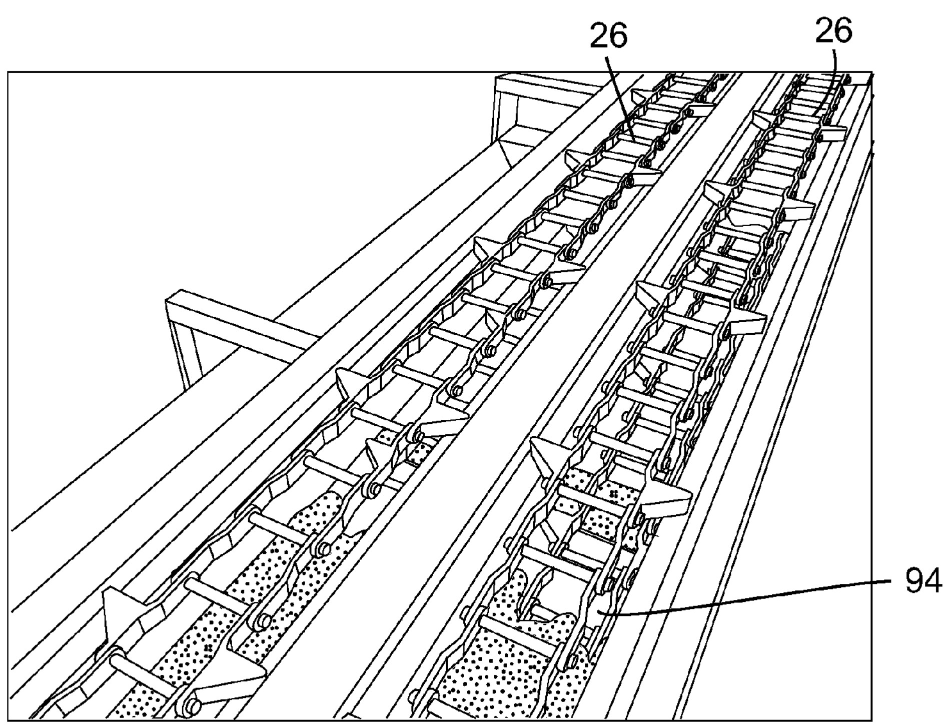


FIG. 15

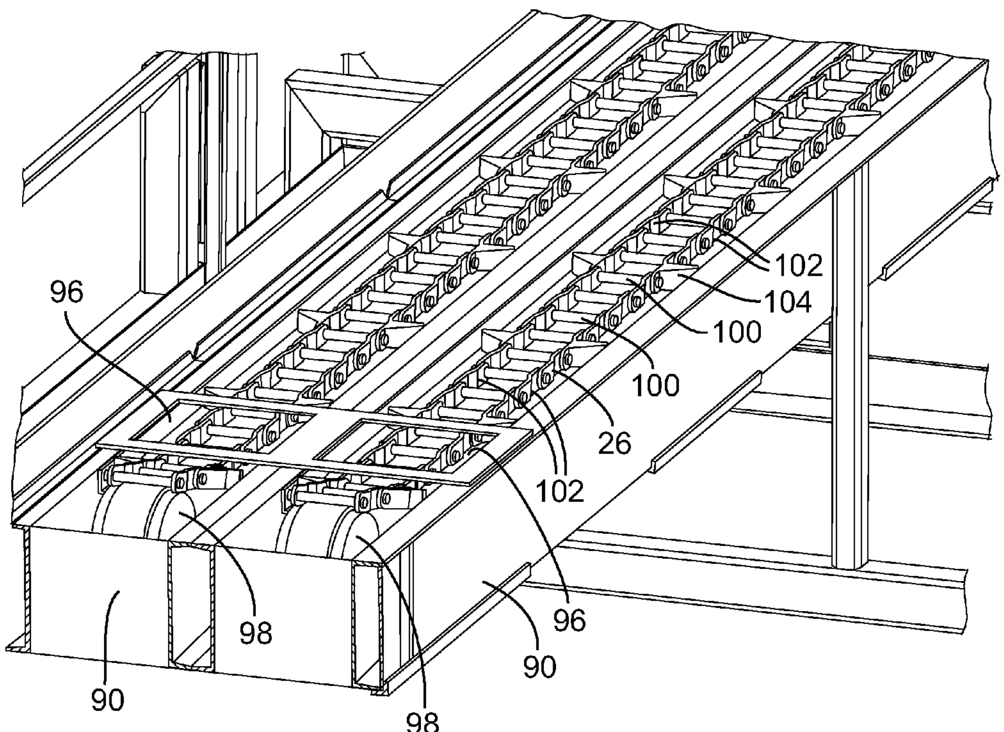
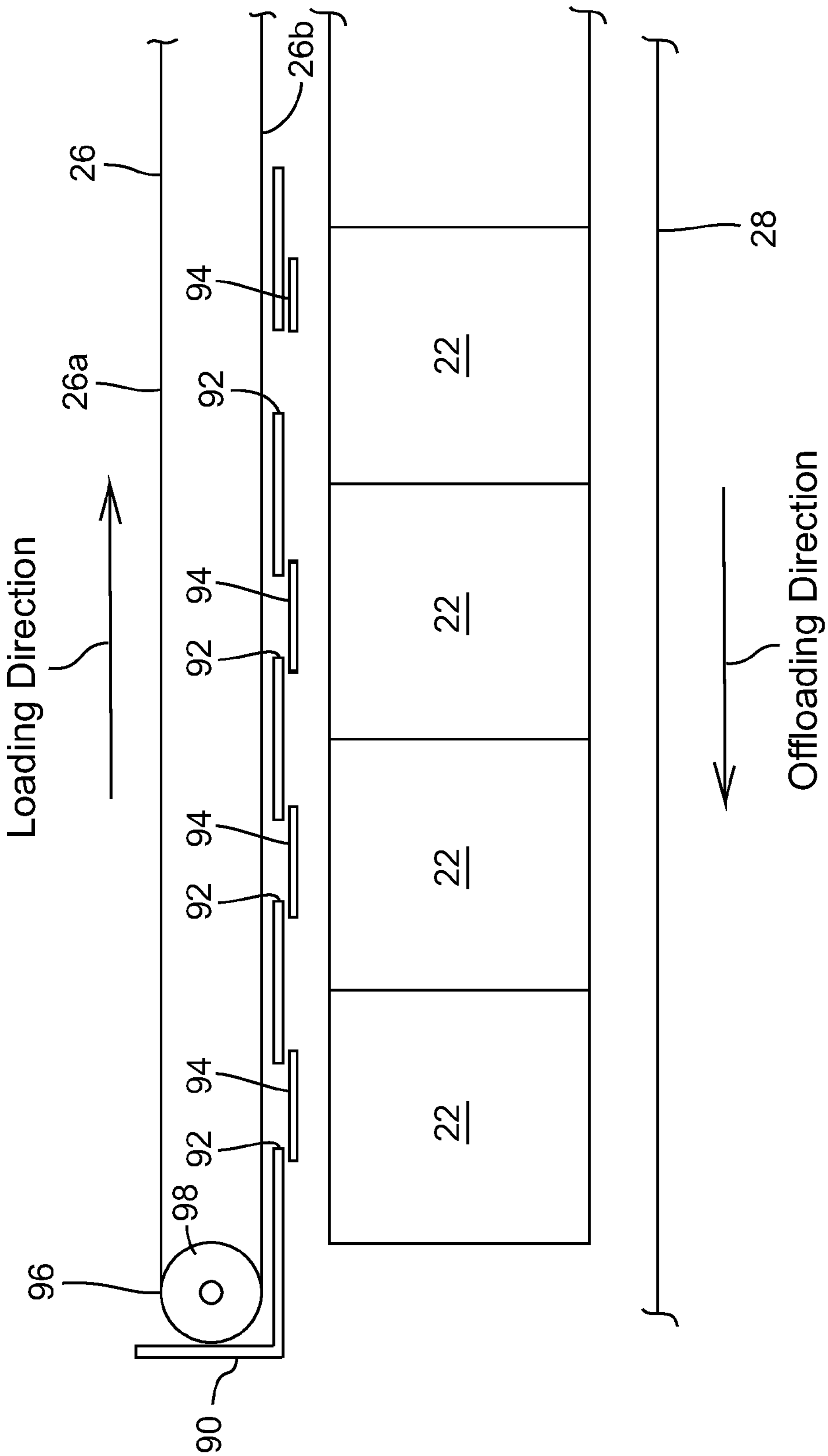


FIG. 16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26b
26a
94
92
28
22
Loading Direction
Offloading Direction
96
98
90

FIG. 17

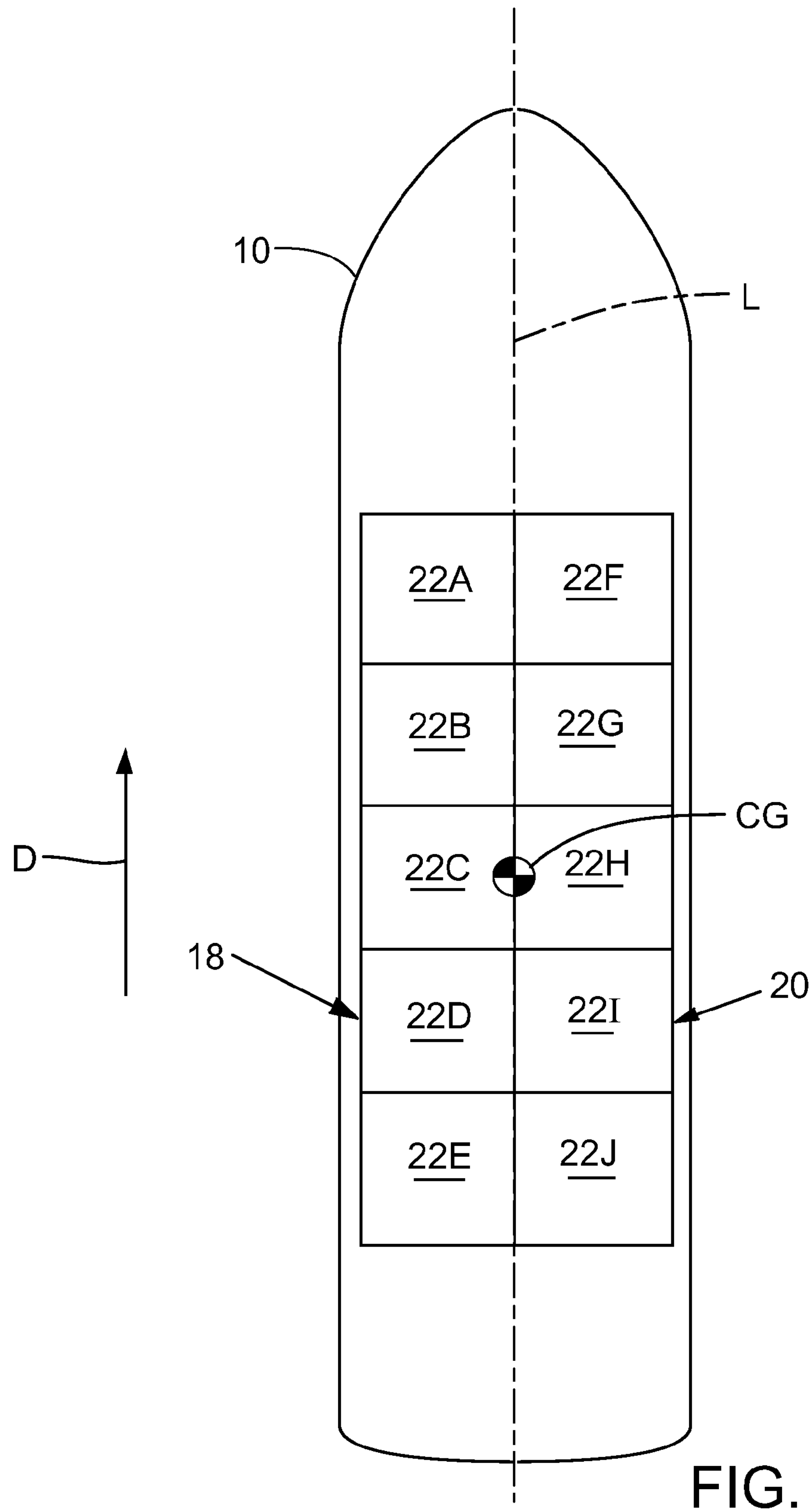

FIG. 18

SYSTEM FOR CONVEYING DRILL CUTTINGS

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application No. 61/654,897, filed Jun. 3, 2012. The provisional application is incorporated herein by reference in its entirety.

FIELD

The present disclosure concerns a system for transporting drill cuttings from an offshore drilling platform.

BACKGROUND

During offshore drilling of wellbores, drill cuttings are circulated to the surface by drilling fluid returning from the bottom of the wellbore. At the surface, various separation and collection equipment is used to separate most of the drilling fluid from the drill cuttings. The drilling fluid is re-used while the drill cuttings are collected for subsequent treatment and disposal. The drill cuttings typically are loaded into storage bins and then transported to shore on a ship. Known loading techniques involve transporting drill cuttings from a drilling rig to storage bins on a ship via a flexible pipe. After each storage bin is filled with drill cuttings, the feed pipe is manually disconnected from the current bin or intake manifold for the current bin and moved to another bin or intake manifold. Typically, the storage bins containing the drill cuttings are offloaded from the ship to the shore using a crane, which is time consuming and requires multiple operators to complete the job. Depending on the size of the ship, the offloading procedure can take about seven days or more to complete. The present disclosure concerns a system for more efficiently transporting the collected drill cuttings from an offshore drilling rig to shore.

SUMMARY

Several embodiments of devices and methods are shown and described herein directed to transporting drill cuttings from an offshore drilling platform. In one representative embodiment, an apparatus for a bulk material storage and conveying system for a ship comprises a first conveyor system including one or more upper conveyors extending lengthwise of the ship. The system also comprises a plurality of containers located below the first conveyor system arranged in one or more rows extending lengthwise of the ship, and a second conveyor system including one or more lower conveyors located below the one or more containers. The first conveyor system is configured to selectively dispense bulk material into the one or more containers, and the plurality of containers are configured to selectively dispense bulk material onto different locations along the length of the one or more lower conveyors.

Another representative embodiment comprises a method of loading drill cuttings onto a ship. The method comprises providing a system for conveying drill cuttings including a conveyor system and a plurality of containers located below the conveyor system, wherein the conveyor system and the plurality of containers extend lengthwise of the ship. The system receives drill cuttings from a drilling rig onto the conveyor system, conveys the drill cuttings along the conveyor system, and dispenses the drill cuttings from the conveyor system into the plurality of containers such that the balance of the ship is maintained during loading.

Another representative embodiment comprises a method of loading drill cuttings onto a ship. The method comprises providing a system for conveying drill cuttings including a conveyor system and a plurality of containers located below the conveyor system, wherein the conveyor system and the plurality of containers extend lengthwise of the ship. The system receives drill cuttings from a drilling rig onto the conveyor system, conveys the drill cuttings along the conveyor system, and dispenses the drill cuttings from the conveyor system into the plurality of containers such that the balance of the ship is maintained during loading. The drill cuttings include multiple types of material from different strata of a wellbore. The drill cuttings can be dispensed such that each container includes multiple layers of different types of material. The drill cuttings can also be dispensed such that pairs of two containers that are equidistant from but on opposite sides of the ship's center of gravity include substantially the same amount of material in each layer of different material that is dispensed into the two containers.

The foregoing and other features and advantages of the invention will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a ship having an onboard drill cutting storage and conveying system anchored adjacent an offshore drilling rig.

FIG. **2** is a top plan view of the drill cutting storage and conveying system of FIG. **1**.

FIG. **3** is a side elevation view of the drill cutting storage and conveying system of FIG. **1**.

FIG. **4** is a cross-sectional view of the drill cutting storage and conveying system of FIG. **1**.

FIG. **5** is an end elevation view of the drill cutting storage and conveying system of FIG. **1**.

FIG. **6** is a perspective view of the drill cutting storage and conveying system of FIG. **1**, shown with the storage bins and enclosures removed for purposes of illustration.

FIG. **7** is a top plan view of the drill cutting storage and conveying system of FIG. **1**, shown with the storage bins and enclosures removed for purposes of illustration.

FIG. **8** is a side elevation view of the drill cutting storage and conveying system of FIG. **1**, shown with the storage bins and enclosures removed for purposes of illustration.

FIG. **9** is an end elevation view of the drill cutting storage and conveying system of FIG. **1**, shown with the storage bins and enclosures removed for purposes of illustration.

FIG. **10** is an enlarged cross-sectional view of a pair of storage bins of the drill cutting storage and conveying system.

FIG. **11** is an enlarged top plan view of a section of a pair of gates covering the outlet opening of a storage bin.

FIG. **12** is a side elevation view of one end of the offloading conveyor.

FIG. **13** is a top plan view showing one end of the ship and vehicles on a dock receiving drill cuttings from the drill cutting storage and conveying system on the ship.

FIG. **14** is a perspective view of a section of a pair of drag chain conveyors being used to convey and dispense drill cuttings into storage bins.

FIG. **15** is another perspective view of a section of the pair of drag chain conveyors.

FIG. **16** is another perspective view of a section of the pair of drag chain conveyors.

FIG. **17** is a schematic, side elevation view showing the operation of a drag chain conveyor being used to dispense drill cuttings into storage bins.

FIG. **18** is a schematic, top plan view of the system of FIG. **1** showing the location of the storage bins relative to the ship's center of gravity and longitudinal center line.

DETAILED DESCRIPTION

FIG. **1** shows a ship **10** anchored adjacent an offshore drilling rig, or platform, **12**. Equipment on the deck of the drilling rig **12** separates drill cuttings from drilling fluid and stores the cuttings, which are then transported to shore via the ship. Mounted on the ship **10** is a drill cutting storage and conveying system **14**, which receives drill cuttings from the drilling rig **12** and then offloads the drill cuttings to land-based equipment for further processing and disposal. Drill cuttings can include clay, mud, soil, rock (e.g., shale, etc.), sand, or other materials representative of the different strata of a wellbore. In some embodiments, drill cuttings can be collected and stored on the drilling rig **12**, where the cuttings may undergo varying degrees of processing (e.g., separation of drilling fluid from the cuttings, drying, etc.) before being transferred to the ship **10**. Alternatively, drill cuttings need not be collected or stored on the drilling rig **12**, but can be transferred from the drilling rig **12** to the ship **10** with minimal or no processing. While the following description proceeds with reference to loading and unloading a ship, it should be understood that the system **14** can be installed on any type of waterborne vessel, including a ship or a barge.

The storage and conveying system **14** in the illustrated embodiment receives drill cuttings from the drilling rig **12** via a conduit **16** (e.g., a flexible pipe). The drilling rig **12** can include equipment that is operable to fluidize the drill cuttings using compressed air and establish a flow of fluidized drill cuttings through the conduit **16** and into the storage and conveying system **14**. However, other techniques or mechanisms can be used to transport the drill cuttings from the drilling rig **12** to the onboard storage system **14**. For example, a system of one or more conveyors can be used to convey the drill cuttings from the drilling rig to the onboard storage system **14**.

Referring to FIGS. **2-4**, the onboard storage system **14** comprises first and second rows **18**, **20**, respectively, of storage bins **22** (also referred to as storage hoppers and containers) placed end-to-end in their respective rows extending lengthwise of the ship. The storage system **14** in the illustrated embodiment includes five storage bins **22** in each row. However, the number of storage bins can vary depending on the volume of drill cuttings to be transported and the overall size of the ship. In addition, the storage system in other embodiments can include one row of storage bins or more than two rows of bins, depending on size and space available on the ship and the volume of drill cuttings to be transported. The bins **22** desirably have a modular construction, meaning that each bin has the same overall size and shape to facilitate assembly and removal and replacement of storage bins when maintenance is required. An enclosure, or cover, **24** may be mounted above each bin **22** to keep the elements out of the bins.

FIGS. **6-9** show the onboard storage system **14** without the storage bins **22** and the covers **24** for purposes of illustration. As shown, the onboard storage system **14** further includes one or more loading conveyors **26** extending above each row **18**, **20** of bins **22** in a direction parallel to the length of the ship. In the illustrated embodiment, two loading conveyors **26** extend above each row of bins, although a fewer or greater number of conveyors can be positioned above each row of bins depending on the loading requirements. The loading conveyors **26** are operable to convey and dispense cuttings received from the drilling rig **12** into the bins **22**, as further described in detail below.

The storage system **14** also includes an offloading conveyor system for transporting drill cuttings in the storage bins **22** to equipment waiting at the shore. The offloading conveyor system includes at least one offloading conveyor **28** extending below each row **18**, **20** of bins **22** in a direction parallel to the length of the ship. The offloading conveyor system further includes respective inclined conveyors **30** positioned at the ends of the offloading conveyors **28**, a transverse conveyor **32** extending in a traverse direction with respect to the inclined conveyors, and a final offloading conveyor **34** that conveys drill cuttings into vehicles or other equipment waiting at the shore. The operation of the offloading conveyor system is further described in greater detail below.

Referring again to FIG. **1**, each inclined conveyor **30** can be provided with a respective enclosure **42** to keep out the elements. Similarly, the transverse conveyor **32** can be provided with a respective enclosure **44**. An operator cab **46** can be located near the final offloading conveyor **34**. As will be described in greater detail below, the entire process of loading drill cuttings onto the ship and offloading drill cuttings from the ship onto vehicles waiting at the shore can be accomplished with a single operator. The operator can control various components of the storage system **14** via a controller **40** (depicted schematically in FIG. **6**) which can be located at a convenient location, such as in the operator cab. The controller **40** can be a general purpose computing device, such as a desk top or lap top computer, a tablet computer, or smart phone. The controller **40** is in communication with various components of the storage system **14**, including the loading and offloading conveyors, via wireless or hard-wired communication links.

As best shown in FIG. **4**, each enclosure **24** above a respective bin **22** houses a portion of a walkway or operator platform **36** above the bin **22**. The enclosures **24** are placed end-to-end to form an elongated enclosed structure, much like a tunnel, extending above each row of storage bins **22**. Each platform **36** desirably extends through the enclosed structure along the entire length of the row of storage bins **22** to allow an operator to access and inspect the area above storage bins.

As noted above, drill cuttings from the drilling rig **12** can be transferred to the ship via a flexible conduit **16** extending from the drilling rig **12**. The end of the conduit **16** can be connected to an inlet conduit **80** on the ship (best shown in FIGS. **1** and **2**). The inlet conduit **80** in turn is connected to a metering device **82**, which in turn is connected to two outlet conduits **84**, each of which is configured to dispense drill cuttings onto a pair of loading conveyors **26** on one side of the storage system **14**. As shown in FIG. **2**, each outlet conduit **84** can extend downwardly through an adjacent enclosure **24** toward the inlet ends of the loading conveyors **26**. The metering device **82** desirably is configured to meter substantially equal amounts of drill cuttings to each row **18**, **20** of storage bins through respective outlet conduits **84**, and can meter drill cuttings to the rows **18**, **20** of storage bins individually or at the same time.

When the metering device **82** dispenses drill cuttings to one row of storage bins, the loading conveyors **26** corresponding to the row of storage bins not receiving drill cuttings can be idled or otherwise rendered in a non-operational state. For example, when the metering device **82** is dispensing drill cuttings to the first row **18** of storage bins **22**, the loading conveyors **26** corresponding to the first row **18** can be in an operational state and the loading conveyors **26** corresponding to the second row **20** of storage bins **22** can be idled. Similarly, when the metering device **82** changes from dispensing drill cuttings to the first row **18** of storage bins **22** to dispensing drill cuttings to the second row **20** (e.g., to maintain the balance of the ship during loading), the loading conveyors **26** corresponding to the second row **20** of storage bins **22** can be in an operational state and the loading conveyors **26** corresponding to the first row **18** can be idled. Operating the loading conveyors in this manner can avoid unnecessary waste of fuel and wear and tear on the machinery.

Referring to FIGS. **14-17**, each outlet conduit **84** can feed two dispensing conduits **88** (FIG. **14**), the lower ends of which can be positioned above inlet ends **96** of corresponding loading conveyors **26**. As best shown in FIG. **16**, each loading conveyor **26** can be positioned within a respective U-shaped trough **90** that extends above a row of storage bins **22**. Each loading conveyor **26** extends around a pulley or sprocket **98** at its opposite ends, forming a continuous loop defining an upper section **26***a* and a parallel lower section **26***b* (FIG. **17**). The loading conveyor **26** can be a drag chain conveyor comprising spaced apart, parallel lugs **100** connected to each other by articulating links **102**. The conveyor can further include teeth **104** extending outwardly from selected links **102** (e.g., on every fourth link **102**) on opposite sides of the conveyor.

When drill cuttings are loading onto the ship, the dispensing conduits **88** dispense drill cuttings above the inlet ends of the troughs. The drill cuttings can fall through the spaces in the drag chain conveyor onto the bottom wall of the trough. The drill cuttings are then dragged along the bottom wall of the trough by the lower section **26***b* of the drag chain. As best shown in FIG. **17**, the bottom wall of the trough **90** has openings **92** spaced along the length of the trough that allow drill cuttings to fall through the trough into the bins **22** below as the drill cuttings are dragged across the bottom wall of the trough. Adjacent each opening **92** is a respective gate **94** (also referred to as a trap door), which can be under the control of the controller **40**. Each gate **94** is configured to move between a closed position covering its respective opening **92** to prevent drill cuttings from falling through the opening and an open position to allow drill cuttings to fall through the opening into the bin below. The gates **94** can be moved between their open and closed positions by respective hydraulic cylinders or equivalent mechanisms operatively connected to each of the gates.

The pair of conveyors **26** above a row of bins can be operated in unison to convey drill cuttings into selected bins of the row. The use of at least two conveyors **26** above each row of bins adds redundancy to the system in case one conveyor malfunctions and requires repair, for example if a chain breaks. Thus, if one of the conveyors **26** malfunctions and causes a built up of drill cuttings in the corresponding dispensing conduit **88**, all of the drill cuttings coming from the common outlet conduit **84** fall under gravity into the other dispensing conduit **88** and onto the other conveyor **26**, which is able to continue the conveying and dispensing process without shutting down the system.

The gates **94** can be operated in a predetermined sequence to ensure that the balance of the ship is maintained during the loading process. Each of the storage bins **22** can have one or more sensors, such as optical sensors and/or scales, that can detect the amount of drill cuttings that has been loaded into each of the bins. In particular embodiments, a 3D sensor can be mounted in or above each bin so as to be able to sense the height and topography of the drill cuttings in each bin. The 3D sensors can be used to generate images of the drill cuttings in each bin, which can be displayed on a monitor (e.g., a monitor of the controller **40** or another device). 3D sensors are known in the art and utilize a radiation source (such as infrared radiation source) to sense the topography of an object.

The sensors and/or scales are in communication with the controller **40** to ensure that each bin is filled at substantially the same rate. For example, the loading process can comprise loading a predetermined first bin **22** (which can be any of the bins) to a predetermined height, or until the weight of cuttings in the first bin **22** reaches a predetermined weight. At this point, the controller **40** opens the gate **94** of a second bin **22** that is the same distance from the ship's center of gravity CG (FIG. **18**) as the first bin but on the opposite side of the ship's center of gravity from the first bin. The second bin **22** can be on the same side or opposite side of the ship's center line L (FIG. **18**) from the first bin. The gate **94** of the second bin remains open until it is filled to the same height as the first bin. The controller **40** repeats this process with additional pairs of bins that are equidistant from the ship's center of gravity until each bin has approximately the same amount of drill cuttings. The foregoing process of partially filling opposing pairs of bins is then repeated until each bin is filled to capacity or there are no more drill cuttings being transferred from the drilling rig **12**. If at any time during the loading process one of the gates **94** over a particular bin fails to close, that bin can be filled and the drill cuttings on the conveyor are simply conveyed over the material in the filled bin and dispensed into a selected downstream bin. If one of the gates **94** fails and cannot be opened, the controller determines the amount of drill cuttings that has been dispensed into that bin, if any, and only allows the same amount of drill cuttings to be loaded into a bin that is on the opposite side of ship's center of gravity and longitudinal center line L.

The overall weight or predetermined height of drill cuttings dispensed into a bin during each pass typically depends on the size of the ship. For a relatively large ship, a relatively large amount of drill cuttings can be dispensed into each bin during each pass. For a relatively smaller ship, a relatively smaller amount of drill cuttings can be dispensed into each bin during each pass to ensure the balance of ship is maintained.

Where less precision is required, such as because a relatively large ship is being loaded, the bins can be loaded by opening and closing the gates **94** for a predetermined period of time. This allows dispensing of approximately equal amounts of drill cuttings into the bins without the use of a feedback loop involving the sensors measuring the height and/or weight of drill cuttings in the bins.

The system **14** can also be configured to dispense drill cuttings comprising different materials into different bins **22**. For example, when drill cuttings being transferred from the drilling rig **12** comprise a particular material, such as clay, the controller **40** can operate the gates **94** of the conveyors **26** such that each bin **22** contains substantially equal amounts of clay. When the type of material changes, for example, from clay to rock, the controller **40** can operate the gates **94** of the conveyors **26** such that each bin **22** contains substantially equal amounts of rock in addition to the clay. In this manner, each bin **22** (or pairs of bins on opposite sides of and equidistant from the ship's center of gravity) can include multiple layers of drill cuttings of different material from the different strata of a wellbore. The drill cuttings can be offloaded from the bins in the same sequence that they were filled, thereby allowing separation of the different types of material so that each vehicle or container on shore can be filled with substantially one type of material.

Alternatively, the system **14** can be configured to dispense particular types of material into particular bins. For example, a select bin or bins **22** (e.g., selected pairs of bins on opposite sides of and equidistant from the ship's center of gravity) can be partially or completely filled with a single material (e.g., when select bins have equipment for handling particular materials, such as agitators for handling clay or mud). In some embodiments, the drill cuttings material type and the approximate quantity of each material can be identified on the drilling rig **12** and communicated to the controller **40** before transfer of the drill cuttings to the ship **10**. Alternatively, the controller **40** can differentiate and dispense different materials into different bins **22** by, for example, weight, as measured by scales **67** positioned under the conveyors **26** (see FIG. **8**). Additionally, the controller **40** can be configured to record the sequence in which bins **22** are filled with drill cuttings, along with the type of material and/or the amount (e.g., weight, volume, etc.) of drill cuttings dispensed. In this manner, the bins **22** can be emptied in substantially the same order in which they were filled, helping to maintain the balance of the ship during offloading.

In some cases, different types of drilling fluid, such as water-based drilling fluid and oil-based drilling fluid, may be used on the same wellbore. For instance, a water-based drilling fluid may be used for drilling through mud and clay, and oil-based drilling fluid may be used for drilling through rock and shale. In such cases, it is possible to separate the drill cuttings into the bins based on the cutting fluid used for that strata of the wellbore. For example, all drill cuttings mixed with a water-based drilling fluid (e.g., mud and clay) can be selectively dispensed into selected pairs of bins on opposite sides of and equidistant from the ship's center of gravity, while all drill cuttings mixed with an oil-based drilling fluid (e.g., rock or shale) can be dispensed into other selected bins to prevent mixing of the two different types of cutting fluid. Where drill cutting materials are separated into the storage bins based on the type of drilling fluid, offloading the bins in the same sequence that they were filled allows the drill cuttings to be offloaded and separated into separate trucks or bins on the shore based on the type of material and the type of drilling fluid. For example, each truck can be loaded with only one type of drill cutting material or filled with different types of drill cutting material mixed with the same drilling fluid. As can be appreciated, this greatly facilitates the disposal and/or recycling process of the drill cutting materials.

The system **14** can include one or more tilt sensors configured to sense the pitch and/or roll of the ship. The tilt sensors can comprise, for example, mercury switches, inclinometers, accelerometers, etc., and can be in communication with the controller **40**. In this manner, the controller **40** can alter the sequence in which the bins **22** are being loaded in real time in response to data about the pitch and/or roll of the ship to maintain the balance of the ship during loading and offloading.

A significant advantage of the disclosed system is that it needs only a single intake pipe to receive drill cuttings from the conduit **16**. During the entire loading procedure, the conduit **16** remains connected to the inlet conduit **80**, which in turn can dispense drill cuttings to all of the bins on the ship. Unlike prior art systems, the conduit **16** need not be manually disconnected and re-connected to another manifold after each bin or set of bins is filled, resulting in significant time savings and much less operator involvement. Moreover, accurate and precise control over the amount of drill cuttings can be achieved with little or no operator involvement. Further, in certain embodiments, a person on the drilling rig **12** can have a separate controller, which can be in the form of a personal computer, such as tablet or laptop computer or smart phone, which can be in communication with the controller **40** and/or the various sensors of the system **14**. In that way, a person on the rig can monitor the amount of drill cuttings in the bins and can adjust the rate at which drill cuttings are transported to the ship via the conduit **16**.

Referring now to FIG. **10**, each storage bin **22** in the illustrated embodiment can include at least one pair of opposing gates **50** that cover an outlet opening at the bottom of the bin. Each gate **50** is movable between a closed position to retain drill cuttings C within the bin (as shown on the left in FIG. **10**) and an open position to allow drill cuttings C to fall through the outlet of the bin onto the offloading conveyor **28** (as shown on the right in FIG. **10**). Each gate **50** can be operatively coupled to a hydraulic cylinder **52** that is configured to move the gate between the open and closed positions, or between the closed position and a partially open position that is intermediate the fully closed and open positions. In alternative embodiments, other mechanisms can be used to effect movement of the gate, such as electric motors, pneumatic cylinders and equivalent mechanisms.

As best shown in FIG. **3**, each storage bin **22** can be provided with a total of four pairs of gates **50** positioned end-to-end underneath the outlet of the bin **22**, although a fewer or greater number of pairs of gates can be used. Utilizing multiple pairs of gates **50** under each bin allows the contents of each bin to be emptied onto the offloading conveyor **28** in a controlled manner, as further described below. In other embodiments, a single pair of gates **50** can cover the entire extent of the outlet opening of a bin, or a single gate can be used to cover the entire extent of the outlet opening of a bin.

Referring again to FIG. **10**, the gates **50** desirably are tilted downwardly moving in a direction from the sides of the bin toward the center of the bin where the inner edges **54** of the gates can contact each other or come into close proximity to each other when the gates are closed. In this manner, the gates **50** direct residual drilling fluid F in the bin to flow downwardly toward the adjacent edges **54** of the gates. As shown in FIG. **11**, the edges **54** can be formed with scallops or recesses **56** that are large enough to allow residual drilling fluid F to fall through the gates and onto the conveyor **28** below, but small enough to retain the drill cuttings in the bin. In this manner, the scalloped edges **56** function as a filter or sieve that separates the residual drilling fluid from the drill cuttings. In lieu of or in addition to the scalloped edges **56**, the gates **50** can be formed with apertures, or openings, that are sized to retain the drill cuttings in the bin and allow drilling fluid to flow through the gates.

One or more of the bins **22** can also include agitators **74**, as shown in FIGS. **4** and **10**. The agitators **74** can be located near the bottom of the bins **22** above the outlet opening, and can comprise a rotatable shaft **76** having one or more protrusions or paddles **78**. When the shaft **76** is rotated, the paddles **78** can agitate the drill cuttings C, which can facilitate dispensing of the drill cuttings from the bins **22** onto the offloading conveyor **28** when the gates **50** are opened. In some embodiments, each bin **22** can include an agitator **74**. Alternatively, agitators **74** can be included with select bins configured for handling specific materials, such as materials prone to clogging the outlet opening during offloading (e.g., clay, mud, etc.). Additionally, each respective agitator **74** can be configured to turn on when the gates **50** of the respective bin **22** are opened, and to turn off when the gates **50** of the respective bin **22** are closed, regardless of the operational state of agitators in adjacent bins.

The offloading conveyor **28** desirably has a support **58** with inclined side walls **60** that extend upwardly from a central bottom wall in order to better contain the fluid F or the cuttings C on the conveyor **28**, as the case may be. After the drill cuttings are offloaded from the drilling rig **12** and loaded into the bins **22**, residual drilling fluid F is allowed to collect on the conveyor **28**, as depicted on the left hand side of FIG. **10**. During the loading process described above and during transport of the drill cuttings to shore, the conveyor **28** can be periodically operated to convey the collected drilling fluid F into a holding tank **64** (FIG. **12**). The drilling fluid collected in the holding tank **64** can be pumped back onto the drilling rig **12** for re-use. Typically, the conveyor **28** is operated in a direction opposite to its normal operating direction when it is used to offload drill cuttings from the ship. Thus, the holding tank **64** typically is positioned at the end of the storage system **14** opposite the inclined conveyors **30**, as depicted in FIG. **7**.

When the ship **10** arrives at its intended docking location, the contents of the storage bins **22** can be transferred onto storage equipment on the shore. The gates **50** at the bottom of the bins can be opened in a predetermined sequence to maintain the balance of the ship as the drill cuttings are released from the bins and conveyed off of the ship. For example, the bins **22** typically are not emptied sequentially along the length of the ship. Instead, a pair of bins **22** on opposite sides of and equidistant from the center of gravity of the ship can be emptied one after on opposite sides of and equidistant from the center of gravity of the ship can be emptied one after the other or at the same time before another pair of bins that are equidistant from the ship's center of gravity are emptied (the bins of each pair are desirably in separate rows on opposite sides of the ship's longitudinal center line L but could be in the same row). As mentioned above, each bin **22** can be provided with multiple pairs of gates **50**. Thus, the offloading procedure can include partially emptying bins in a predetermined sequence, which helps avoid overloading the conveyor **28**. The operation of the gates **50** and the offloading conveyor **28** can be under the control of the controller **40**.

The offloading system can be provided with sensors that detect for the presence of drill cuttings on the conveyor **28** and provide feedback to controller **40** for controlling the operation of the gates **50**. In the illustrated embodiment, for example, a plurality of sensors **66** are placed along the length of each conveyor **28**, such as at equally spaced locations adjacent one end of each bin **22**, as shown in FIG. **7**. The sensors **66** can be optical sensors that are configured to detect the presence of drill cuttings on the conveyors **28**. The sensors **66** are in communication with the controller **40**, which operates the gates **50** of the bins to ensure that the contents of each bin is dispensed onto an empty section of a conveyor **28** and is not dispensed on the contents of another bin already dispensed onto the conveyor **28**.

In operation, drill cuttings are dispensed from a predetermined bin **22** onto a conveyor **28** and conveyed toward the inclined conveyors **30** (as indicated by the direction of arrow **68** of FIG. **7**). As the drill cuttings on the conveyor **28** pass the sensors **66**, each sensor **66** provides a corresponding feedback signal to the controller **40**, telling the controller whether a section of the conveyor immediately upstream of the sensor is clear, or substantially clear of drill cuttings. In particular embodiments, the sensors **66** can comprise 3D sensors that are configured to determine an amount of drill cuttings on a section of the conveyor and/or to provide a visual image of the drill cuttings to the user. If the section of the conveyor **28** underneath the next bin in the sequence is clear, or substantially clear of drill cuttings, the controller **40** will control the gates **50** of that bin **22** to dispense drill cuttings onto the conveyor **28**. In alternative embodiments, other techniques and mechanisms can be used to detect for the presence of drill cuttings on sections of a conveyor **28**. For example, scales can be positioned at selected locations underneath a conveyor to measure the weight of any drill cuttings that are present along the length of the conveyor. Another mechanism can be used to determine the force required to move the conveyor, which provides an indication of the presence of drill cuttings on the conveyor. For example, transducers can be operatively connected to the hydraulic mechanisms that drive the conveyors **28**. The transducers can detect the hydraulic pressure of the drive mechanisms and convert the pressure measurement into a signal indicative of the load present on the conveyors.

In the event that one or more bins **22** fail to dispense drill cuttings onto the conveyor **28** during offloading, the controller **40** can be configured to prevent the corresponding bin or bins on the opposite side of the ship's center of gravity and/or longitudinal center line from dispensing drill cuttings until manually overridden by an operator. The failure of a bin **22** to dispense drill cuttings can be due to, for example, failure of one or more gates **50** to open. The controller **40** can be configured to detect a failure of a bin **22** to dispense drill cuttings in a variety of ways, including receiving an indication from a gate **50** that the gate has failed to move from the closed position to the open position, receiving data from the sensors **66** indicating a lack of drill cuttings on the conveyor **28**, receiving data from scales indicating a lack of drill cuttings on the conveyor **28**, or receiving data from sensors in the bin(s) indicating no change in the amount of drill cuttings present in the bins after the controller **40** has transmitted instructions to open one or more gates **50**. In this manner, the controller **40** can alter the predetermined sequence in which the drill cuttings are offloaded to maintain the balance of the ship in the event that one or more bins **22** fail to dispense drill cuttings onto the conveyor **28**, regardless of whether an operator is aware of the failure. Similarly, if a bin **22** is only partially evacuated, such as because a gate does not fully open or material becomes clogged inside the bin, the controller can detect the amount of the drill cuttings dispensed from the bin, such as from feedback signals received from the sensors or scales, and control the bin on the opposite side of the ship's center of gravity (and desirably on the opposite side of the ship's longitudinal center line L) to dispense the same amount of drill cuttings onto the conveyor.

Still referring to FIG. **7**, drill cuttings on the offloading conveyors **28** are conveyed onto respective inclined conveyors **30**, which in turn convey drill cuttings onto the transverse conveyor **32**. The transverse conveyor **32** can include a scale to measure the total weight of the drill cuttings being offloaded from the ship. Drill cuttings on the transverse conveyor are then conveyed onto the final offloading conveyor **34**.

Referring now to FIGS. **5** and **13**, the offloading conveyor **34** can be positioned by an operator to convey drill cuttings into one or more vehicles **70** (e.g., trucks with storage bins) that are parked in the dock area adjacent the ship. The offloading conveyor **34** desirably is pivotable about its base **72** in a side-to-side direction as well as the up-and-down direction. Desirably, the offloading conveyor **34** is pivotable side-to-side at least through **180** degrees and is pivotable up and down at least through **90** degrees to facilitate positioning the upper, free end of the conveyor **34** above a waiting vehicle **70**. A video camera can be mounted on the upper end of the conveyor **34** to assist the operator in positioning the upper end of the conveyor **34** at a desired location above the vehicle **70**. Because the conveyor **34** has three degrees of movement and can be easily positioned by the operator, it is not necessary to have the vehicle precisely located at a predetermined location with respect to the conveyor.

After the present vehicle is filled to capacity with drill cuttings, that vehicle is driven away, the operator temporarily discontinues the offloading process, another vehicle is driven into the general vicinity of the conveyor **34**, and the operator aligns the conveyor **34** above the empty vehicle and continues the offloading process. This process can be repeated with additional trucks until the entire contents of the bins **22** are offloaded from the ship. In this manner, drill cuttings can be offloaded from the ship **10** in less than a day, resulting in significant time and cost savings over conventional drill cutting transport and offloading techniques, which can take seven days or more to complete. Additionally, the scale on the offloading conveyor **34** can allow the operator and/or the controller **40** to precisely track the weight of drill cuttings offloaded onto each vehicle **70** to avoid overloading the vehicle.

In particular embodiments, the offloading conveyor **34** can be configured to dispense a predetermined amount of drill cuttings into each truck, such as based on the maximum load capacity of the truck. When the drill cuttings being offloaded exceed a predetermined weight as measured by the scale, the offloading conveyor **34** is then turned off.

The following examples are provided to illustrate certain features of working embodiments. A person of ordinary skill in the art will appreciate that the scope of the present invention is not limited to the scope of the features exemplified by these examples.

Example 1

In a first example of operating the system, a ship **10** is provided having a center of gravity G, a longitudinal center line L, and the drill cuttings storage and conveyor system of FIG. **1**, as shown schematically in FIG. **18**. The storage and conveyor system includes a first row **18** of storage bins **22**A-**22**E and a second row **20** of storage bins **22**F-**22**J, the first and second rows **18**, **20** being arrayed about the center of gravity CG and located on opposite sides of the ship's longitudinal center line L.

During a loading process, drill cuttings are transferred to the ship **10** from a drilling rig by a conduit **16**, as depicted in FIG. **1**. A metering device **82** (FIG. **1**) onboard the ship **10** meters the drill cuttings onto loading conveyors positioned above the rows **18**, **20** of storage bins. A controller **40** (FIG. **6**) operates the loading conveyors and gates located along the length of the loading conveyors according to a predetermined sequence. The controller transmits control signals to the metering device causing the metering device to meter drill cuttings onto the loading conveyors of the first row **18** of storage bins, and transmits control signals to gates in the loading conveyors located above a bin at the end of the row **18**, such as storage bin **22**A, causing the gates to open. Drill cuttings are thereby dispensed from the loading conveyors through the gates and into storage bin **22**A. When the level of drill cuttings in bin **22**A reaches a predetermined height, the controller transmits control signals causing the gates above bin **22**E to open and causing the gates above bin **22**A to close. Drill cuttings are thereby dispensed from the loading conveyors into bin **22**E.

When the level of drill cuttings in bin **22**E reaches a predetermined height, the controller transmits control signals causing the gates above bin **22**E to close and causing the gates above bin **22**B to open. Drill cuttings are thereby dispensed from the loading conveyors into bin **22**B. This procedure is repeated for dispensing drill cuttings into bins **22**D and **22**C.

When the bins **22**A-**22**E of row **18** have been loaded with drill cuttings, the controller transmits control signals to the metering device causing the metering device to cease metering drill cuttings onto the loading conveyors of row **18** and to begin metering drill cuttings onto the loading conveyors of row **20**. The controller also transmits control signals causing the loading conveyors of row **20** to enter an operational state, causing the gates above a bin at the end of the row **20**, such as bin **22**F, to open, and causing the loading conveyors of row **18** to shut down or enter an otherwise idle or non-operational state. Bins **22**F-**22**J can then be loaded in the same sequence as described above with respect to bins **22**A-**22**E. This process is repeated with each bin until the ship **10** is fully loaded or there are no more drill cuttings being transferred from the drilling rig. When the ship **10** reaches its destination, the bins **22**A-**22**J can be unloaded in substantially the same order in which they were loaded. In another example, any one of bins **22**E, **22**F, or **22**J can be loaded first, with the loading sequence proceeding in substantially the same pattern as described above. In another example, the system can be operated such that the ship **10** is loaded from the center outwardly toward the ends (e.g., bin **22**C is loaded first, followed by, for example, bin **22**B, bin **22**D, etc.).

The loading sequence described above is most appropriate for a system having a single row of bins aligned along the longitudinal center line L of the ship. When more than one row of bins on opposite sides of the longitudinal center line L are present, the ship may become unbalanced with respect to the longitudinal center line L as material is added to the first row of bins. In such cases, the control can detect the tilt of the ship and begin dispensing drill cuttings in the second row of bins if the ship's tilt exceeds a predetermined amount.

Example 2

Referring again to FIG. **18**, in a second example of operating the system, the metering device onboard the ship **10** meters drill cuttings from a drilling rig onto loading conveyors positioned above the rows **18**, **20** of storage bins **22**A-**22**E and **22**F-**22**J, respectively. The controller operates the loading conveyors and gates located along the length of the loading conveyors according to a predetermined sequence. The controller transmits control signals to the metering device causing the metering device to meter drill cuttings onto the loading conveyors of the first row **18** of storage bins, and transmits control signals to gates in the loading conveyors located above, for example, storage bin **22**A, causing the gates to open.

Drill cuttings are dispensed from the loading conveyors through the gates and into storage bin **22**A. When the level of drill cuttings in bin **22**A reaches a predetermined height, the controller transmits control signals causing the gates above bin **22**E to open and causing the gates above bin **22**A to close. Drill cuttings are thereby dispensed from the loading conveyors through the gates and into bin **22**E.

When the level of drill cuttings in bin **22**E reaches a predetermined height, the controller transmits control signals to the metering device causing the metering device to cease metering drill cuttings onto the loading conveyors of row **18** and to begin metering drill cuttings onto the loading conveyors of row **20**. The controller also transmits control signals causing the loading conveyors of row **20** to enter an operational state, causing the gates above, for example, bin **22**F to open, causing the gates above bin **22**E to close, and causing the loading conveyors of row **18** to shut down or enter an otherwise idle or non-operational state.

The metering device continues to meter drill cuttings onto the loading conveyors of row **20**, which continues to convey and dispense the drill cuttings into bin **22**F until the level of drill cuttings in bin **22**F reaches a predetermined height. The controller then transmits control signals causing the gates above bin **22**J to open and causing the gates above bin **22**F to close. Drill cuttings are thereby dispensed into bin **22**J.

When the level of drill cuttings in bin **22**J reaches a predetermined height, the controller transmits control signals to the metering device causing the metering device to cease metering drill cuttings onto the loading conveyors of row **20** and to begin metering drill cuttings onto the loading conveyors of row **18** again. This procedure is repeated for dispensing drill cuttings into bins **22**B and **22**D, and then bins **22**G and **22**I. In this manner, the bins are loaded in a sequence that balances the load with respect to the longitudinal center line L. Bins **22**C and **22**H are loaded last, and the process is repeated as necessary until the ship **10** is fully loaded or there are no more drill cuttings to be transferred from the drilling rig. When the ship **10** reaches its destination, the bins **22**A-**22**J can be unloaded in substantially the same order in which they were loaded. In another example, any one of bins **22**E, **22**F, or **22**J can be loaded first, with the loading sequence proceeding in substantially the same pattern as described above. In another example, the rows of bins are loaded from the center outwardly towards the ends, such that bins **22**C and **22**H are loaded first, followed by bins **22**B and **22**D, followed by bins **22**G and **22**I, and so on.

Example 3

Referring again to FIG. **18**, in a third example of operating the system, the metering device onboard the ship **10** meters drill cuttings from a drilling rig onto loading conveyors positioned above the rows **18**, **20** of storage bins **22**A-**22**E and **22**F-**22**J, respectively, at the same time. The controller operates the loading conveyors and gates located along the length of the loading conveyors according to a predetermined sequence. The controller transmits control signals to the metering device causing the metering device to meter drill cuttings onto the loading conveyors of the first row **18** and the second row **20** of storage bins.

The controller transmits control signals to gates in the loading conveyors of rows **18**, **20** located above, for example, storage bins **22**C and **22**H, respectively, causing the gates to open. Drill cuttings are dispensed from the loading conveyors through the gates and into storage bins **22**C and **22**H. When the level of drill cuttings in bins **22**C and **22**H reaches a predetermined height, the controller transmits control signals causing the gates above bins **22**D and **22**I to open and causing the gates above bins **22**C and **22**H to close. Drill cuttings are thereby dispensed into bins **22**D and **22**I. When the level of drill cuttings in bins **22**D and **22**I reaches a predetermined height, the controller transmits control signals causing the gates located above bins **22**B and **22**G to open and causing the gates above bins **22**D and **22**I to close. Drill cuttings are thereby dispensed into bins **22**B and **22**G.

This procedure is repeated for dispensing drill cuttings into bins **22**E and **22**J, and bins **22**A and **22**F. The process is repeated as necessary until the ship **10** is fully loaded or there are no more drill cuttings to be transferred from the drilling rig. When the ship **10** reaches its destination, the bins **22**A-**22**J can be unloaded in substantially the same order in which they were loaded. In another example, the system can be operated such that bins **22**A and **22**F or bins **22**E and **22**J are loaded first, followed by the respective pair of bins located equidistant from and on the opposite side of the center of gravity CG of the ship **10**, and so on.

Example 4

Referring again to FIG. **18**, in a fourth example of operating the system, drill cuttings are loaded into pairs of bins that are equidistant from the ship's center of gravity and on opposite sides of the ship's longitudinal center line L and the center of gravity. For example, drill cuttings can be dispensed first into bin **22**A of the first row to a predetermined height, and then into bin **22**J of the second row. The process is then carried out for bins **22**E, **22**F, bins **22**B, **22**I, bins **22**D, **22**G, and finally bins **22**C, **22**H. The entire process can be repeated as desired until the desired load is dispensed into each bin. In another example, the process can begin with bins **22**C, **22**H, followed by bins **22**B, **22**I, bins **22**D, **22**G, and so on. In yet another example, pairs of bins on opposite sides of the ship's center of gravity and the longitudinal center line L can be loaded simultaneously. For example, bins **22**A and **22**J can be loaded simultaneously to a predetermined height, followed by bins **22**E and **22**F, and so on. It can be appreciated that the exact loading procedure can be selected based on the degree of precision required to maintain the balance of the ship.

Example 5

Referring again to FIG. **18**, in a fifth example of operating the system, the drilling rig contains a known quantity of drill cuttings comprising materials from different strata of a wellbore (e.g., clay, sand, rock, etc.) stored onboard the drilling rig. Using data regarding the type and quantity of drill cuttings, known quantities of drill cuttings can be loaded into the bins **22**A-**22**J according to any of the sequences of Examples 1-4 above. The bins can be loaded such that pairs of bins in the same row and pairs of bins in different rows that are equidistant from the center of gravity CG can have similar layering of drill cuttings (i.e., pairs of bins equidistant from the center of gravity CG can have substantially equal amounts of drill cuttings of the same type of material). For example, pairs of bins equidistant from the center of gravity CG at or near the ends of a row can be filled with substantially equal amounts of clay, sand and/or rock, while bins closer to the center of gravity CG can be filled with substantially equal amounts of rock.

General Considerations

For purposes of this description, certain aspects, advantages, and novel features of the embodiments of this disclosure are described herein. The disclosed methods, apparatuses, and systems should not be construed as limiting in any way. Instead, the present disclosure is directed toward all novel and nonobvious features and aspects of the various disclosed embodiments, alone and in various combinations and sub-combinations with one another. The methods, apparatuses, and systems are not limited to any specific aspect or feature or combination thereof, nor do the disclosed embodiments require that any one or more specific advantages be present or problems be solved.

Although the operations of some of the disclosed methods are described in a particular, sequential order for convenient presentation, it should be understood that this manner of description encompasses rearrangement, unless a particular ordering is required by specific language. For example, operations described sequentially may in some cases be rearranged or performed concurrently. Moreover, for the sake of simplicity, the attached figures may not show the various ways in which the disclosed methods can be used in conjunction with other methods. As used herein, the terms "a", "an" and "at least one" encompass one or more of the specified element. That is, if two of a particular element are present, one of these elements is also present and thus "an" element is present. The terms "a plurality of" and "plural" mean two or more of the specified element.

As used herein, the term "and/or" used between the last two of a list of elements means any one or more of the listed elements. For example, the phrase "A, B, and/or C" means "A," "B," "C," "A and B," "A and C," "B and C" or "A, B and C."

As used herein, the term "coupled" generally means physically coupled or linked and does not exclude the presence of intermediate elements between the coupled items absent specific contrary language.

In view of the many possible embodiments to which the principles of the disclosed invention may be applied, it should be recognized that the illustrated embodiments are only preferred examples of the invention and should not be taken as limiting the scope of the invention. Rather, the scope of the invention is defined by the following claims. We therefore claim as our invention all that comes within the scope and spirit of these claims.

We claim:

1. A method of loading drill cuttings onto a waterborne vessel, comprising:

receiving drill cuttings from a drilling rig onto a conveyor system extending lengthwise of the waterborne vessel above a plurality of containers;

determining information indicative of the presence of a first drill cuttings material type on the conveyor system;

conveying the drill cuttings along the conveyor system; and

dispensing the drill cuttings from the conveyor system into at least a first container of the plurality of containers based at least in part on the first drill cuttings material type such that the balance of the vessel is maintained during loading;

determining information indicative of the presence of a second drill cuttings material type on the conveyor system; and

dispensing the drill cuttings from the conveyor system into the first container based at least in part on the second drill cuttings material type such that the first container includes drill cuttings of the first and second drill cuttings material types.

2. The method of claim **1**, wherein the act of dispensing comprises dispensing drill cuttings from the conveyor system into the plurality of containers in a predetermined sequence.

3. The method of claim **2**, wherein the predetermined sequence further comprises dispensing drill cuttings from the conveyor system into the first container until the level of drill cuttings reaches a predetermined height, then dispensing drill cuttings into a second container that is equidistant from but on the opposite side of the vessel's center of gravity than the first container.

4. The method of claim **1**, wherein the conveyor system comprises a first conveyor system and a second conveyor system, the first conveyor system being located above the plurality of containers and the second conveyor system being located below the plurality of containers.

5. The method of claim **4**, further comprising unloading the vessel by dispensing the drill cuttings from the plurality of containers onto the second conveyor system in a predetermined sequence such that the balance of the vessel is maintained during unloading.

6. The method of claim **4**, further comprising collecting drilling fluid from the drill cuttings in the first container onto the second conveyor system; and

conveying the collected drilling fluid to a holding tank at one end of the second conveyor system.

7. The method of claim **1**, wherein dispensing the drill cuttings further comprises dispensing the drill cuttings such that at least two containers of the plurality of containers include substantially equal amounts of drill cuttings of the first drill cuttings material type and substantially equal amounts of drill cuttings of the second drill cuttings material type.

8. The method of claim **1**, wherein determining information further comprises receiving information from a drilling rig indicative of the first drill cuttings material type.

9. The method of claim **1**, wherein determining information further comprises determining a weight of the drill cuttings on the conveyor system indicative of the first drill cuttings material type.

10. A controller operable to perform the method of claim **1**.

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